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LEGAL SECURITY AND CREDIBILITY IN AGENT BASED VIRTUAL ENTERPRISES

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Recent trends in the field of Artificial Intelligence, brought along new ways of formalizing and expressing wills and declarations. Its application to Virtual Enterprises requires an analysis of the interactions among agents, frameworks and users, as well as technical and legal analysis, in order to discover the rules to be applied, to solve a particular problem under a prospective scenario. Credibility, trust and security issues must be taken under consideration, especially concerning authenticity, confidentiality, integrity and non-repudiation. In order to increase the use of agents in Virtual Enterprises, besides the analysis and research of legal solutions in the commercial arena, it is essential to assure that agents will meet requirements of credibility and trust, insuring a transparent and secure way for their commercial acting, now capable of generating legal relations. This paper shows how to construct a dynamic virtual world of complex and interacting entities or agents, in which fitness is judged by a quality of information criterion.

1. INTRODUCTION

The use of multi-agent systems in Virtual Enterprises (VE) scenarios pleads in favour of the answers to different and simultaneous user demands, under a secure and error free way. Agents must be able to manage knowledge in terms of beliefs, desires, intentions, expectations, goals and values, but also to plan, receive information, commands or instructions, reacting to environment stimulus, communicating and cooperating with other agents. On the other hand, the agent’s knowledge is generally incomplete, contradictory or error sensitive, being desirable the use of formal tools to deal with incomplete, contradictory, imperfect, wrong, nebulous or missing information.

New developments concerning the roles an agent may play in such environments are arising but, still nowadays, agents are seen as mediators, playing generally passive roles, being used as searching or filtering devices. However, buyer or selling robotic devices are eager for the most advanced computational functionalities that may contribute to abide new users. Under this realm, new agents, working as brokers, initiators of commercial relations and/or generating agreements without human participation, are emerging [17]. These agents will perform an active/participative role in the trading process, and must be taken into consideration.

In order to increase the use of agents in VE, besides the analysis and research of legal solutions in the commercial arena, it is essential to assure that agents will meet requirements of trust and credibility, insuring a transparent and secure way for their commercial acting, now capable of generating legal relations, established by the inner states of an agent and its capability to determine, acquire and express beliefs, desires and intentions, constraining through direct or indirect ways, trust, reputation and credibility [16].

2. LEGAL SECURITY IN E-CONTRACTS

Actually, to speak about contracts there must be two or more declarations of will, containing a consensual agreement, consisting of an offer and of an acceptance. But agents operate in VE without any direct intervention of humans, and they have a control on their own actions and on their own inner states [1]. So, legal difficulties obviously arise in such situations of contracting through the only intervention and interaction of autonomous intelligent systems, capable of acting, learning, modifying instructions and taking decisions [2]. Traditional legal principles have some difficulty to deal with the fact of agents celebrating contracts on their own. We must keep in mind that the used devices can act in such an autonomous way that it may have severe implications in the process of contract formation as we know it. Because intelligent artefacts will not only act according to their built-in knowledge and rules [3] but they also will be able to learn from experience, and to modify its own behaviour, according to cognitive, reactive and pro-active processes quite similar to human acting [1]. So, as Emily Weitzenboeck puts it, “agreements will therefore no longer be generated through machines but by them, without any intervention or supervision of an individual” [3]. And since the program changes overtime, without any human intervention, it would be very difficult to characterize it as the embodiment or expression of human intention” [2].

This leads us to an imperious need of analysing the question of expression of consent in transactions performed by agents. And two main possibilities have been suggested: the possibility of considering these as mere machines or tools, used by its owner, and the daring possibility of considering the agent as a legal person. The first perspective would be simpler to adopt and it seems in accordance with legislation already enacted in the United States and Canada: The US Uniform Electronic Transactions Act (UETA), the Uniform Computer Information Transactions Act (UCITA) and Canada’s Uniform Electronic Commerce Act, which already expressly recognize that a contract may be formed by the interaction of electronic agents. The second possibility, although presenting some practical difficulties, may appear quite fascinating and must be considered. But, for the moment being it is not yet possible to think of the “electronic agents” as legal persons. Should we accept the fiction of considering them as mere tools the humans are using, even knowing humans may not be able to control them? Or is there another solution? Considering that European jurisdictions have not yet decided what regime to adopt concerning electronic agents, it might be wiser to accept the suggestion of Giovanni Sartor, of “…creating companies for on-line trading, which would use agents in doing their business. Such agents would act in the name of a company, their will would count as the will of the company, their legally relevant location would be the company's domicile, and creditors could sue the company for obligations contracted by those agents. The counterparties of an agent could then be warranted by the company capital, and the legal remedies available towards defaulting commercial companies" [4].

But, even considering this, there must also be a link between the commercial act and the agents. Each agent must be identified; i.e., the agent must have access to a signature (e.g., an electronic signature, certified by a trusted third party), allowing an electronic performance of the traditional functions of a signature, such as the identification of the signer, and the manifestation of a will [5], in terms of assuring intention, authenticity and non-repudiation, and also of establishing integrity and certainty of the contents of the issued messages or declarations [6]. The question here is that the agent is not yet a person. Can it therefore use an electronic signature of its own? For the moment being the point is doubtful [7]. In order to avoid difficulties in law interpretation, it would be advisable that law clearly establishes the possibility for agents to use qualified electronic signatures, in order to enhance the use of agents in electronic commerce in a trustable and secure way.

Another important issue is certainly the one related to the proof value of such dematerialized informatics documents. May these documents be admitted to prove a contract before the Court, and if they may what will be its value? Under Portuguese law, the function of evidence is to create a firm belief in the reality of a fact. We know that contracts may be concluded by any means, except in certain situations when law requires a specific form or instrument. But, the general rule in Portuguese law is: if the contract is not subject to a written form, also the proof may be done by any means. Documentary evidence is stated in article 362 of the Civil Code, which defines document as "any material object created by man capable of representing a fact, event, thing or person". Under Portuguese law, electronic documents satisfy the requirement of written form when its contents are capable of being represented as a written declaration (art. 3 nr. 1 Decree 62/2003) and when signed with a qualified electronic signature certified by an accredited certification authority they will have the proof value of a private signed document (art. 3 nr. 2 Decree 62/2003). This kind of signature has the consequence of establishing a legal presumption that not only the signature was used with the intention of signing and that the document was not altered since then, but also that the person who used the signature is the holder of the signature or the legal representative of the company that holds the signature (art. 7 nr. 1 Decree 62/2003). Once again, according to this article, it is quite doubtful that an agent would be considered as entitled to sign on behalf, for instance, of the company that owns the agent. In order to enhance the use of agents, law should be revised accordingly.

Yet, it is possible for parties using electronic agents to agree on a convention in order to establish the acceptance, in their relations, of the electronic documents as proofs of their transactions. The Portuguese Civil Code (art. 345) admits this kind of conventions, with some exceptions [8]. Indeed, as it happens very often, and as it is suggested by Chris Reed, "many of the potential problems, once they are properly identified, can be overcome quite simply through the mechanism of properly drafted contracts" [9]. It is the will of the parties replacing law whenever law just ignores the reality and/or the actual needs of the commercial practice.

Related to the proof value of electronic documents appears the role, each day more and more important, of electronic evidence, in its broader sense, strongly related to the notion of traceability: As Michael Overly refers, “Electronic documents may include word-processing files, spreadsheets, e-mail, records of instant messaging (IM) exchanges, Web pages, online order forms, databases, and digitised pictures, video and audio files” [10]. The idea is that electronic evidence will perform a more and more important role in the subject of proof of electronic contracts.

Also quite relevant for electronic contracting will be to establish the precise time when electronic communications really occurred. Time stamp services, determining the date and hour of an electronic operation [11], will be of utmost importance.

Having the above stated in mind, it is essential to consider that all intervenients and processes in VE also should be seen as secure, trustable, reliable and credible [13, 14, 15, 16].

3. CREDIBILITY

Credibility is a synonym of believability and is not observable in an agent, a person or information, i.e. credibility must be evaluated in a subjective way through the perception of multiple ambiguous dimensions. The majority of researchers identify two key components of credibility: trustworthiness and expertise [12]. In evaluating credibility, a person makes an assessment of both trustworthiness and expertise to arrive at an overall credibility evaluation. To formalize the trustworthiness of an agent, a person or information, one must estimate if it is well-intentioned, truthful, unbiased, honest and good. To formalize expertise, one must estimate if it is experienced, intelligent, powerful, competent and knowledgeable. It is helpful to distinguish four types of credibility [12] even though these distinctions are not considered in the psychology literature and are based upon the information sources for credibility: presumed (based on a mind state), reputed (based on third parties reports), surfaced (based on a simple inspection) or experienced (based on first-hand experience). Credibility is obviously related to legal security.

4. KNOWLEDGE REPRESENTATION

Knowledge representation techniques as a way to describe the real world, based on mechanical, logical or other means, will be, always, a function of the systems ability to describe the existing world. Therefore, in the conception of a knowledge representation system, it must be object of attention [19]:

- Existent Information: it may not be known in all its extension.
- Observed Information: it is acquired by the experience, and obtained by contact or observation.
- Represented Information: with respect to a certain situation, it may be relevant to represent a given set of information. In spite of all the limitations, it is possible that observations made by different individuals, with distinct education and motivations, show the same set of fundamental data, function of its utility.

Prior to the characterization of the agent’s structure in terms of Extended Logic Programming (ELP) productions, the agent's knowledge base has to be addressed. It will be built around a set of logical clauses subject to proof.

Definition. *The knowledge available in each agent's KB is made of logic clauses of the form* $P_{i+j+1} \leftarrow P_1 \wedge P_2 \wedge \ldots \wedge P_{i-1} \wedge not\ P_i \wedge \ldots \wedge P_{i+j}$*, where I, j, k* $\in N_0$, $P_1, \ldots, P_{i+j}$ *are literals, i.e. formula of the form p or* $\neg p$*, where p is atom, and where* r_k*, not,* P_{i+j+1}*, and* $P_1 \wedge P_2 \wedge \ldots \wedge P_{i-1} \wedge not\ P_i \wedge \ldots \wedge P_{i+j}$ *stand, respectively, for the clause's identifier, the* ***negation-as-failure*** *operator, the rule's consequent, and the rule's antecedent. If i=j=0 the clause is called a* ***fact*** *and is represented as* P_1.

i.e., with respect to the computational model it were considered extended logic programs with two kinds of negation, classical negation ¬ and default negation not. Intuitively, not p is true whenever there is no reason to believe p, whereas ¬p requires a proof of the negated literal. An extended logic program (program, for short) is a finite collection of rules r of the form:

$$p \leftarrow p_1, \ldots, p_n, not\ q_1, \ldots, not\ q_m$$

where the pi, qj, and p are classical ground literals, i.e. either positive atoms or atoms preceded by the classical negation sign ¬.

The knowledge base of an agent is taken from an ordered theory OT=(T,(S, <)), where T, S and < stand, respectively, for an agent's knowledge base in clausal form, a set of priority rules, and a non-circular ordering relation over such rules. An argument (i.e. a proof, or series of reasons in support or refutation of a proposition) or arguments have their genesis on mental states seen as a consequence of the proof processes that go on unceasingly at the agent's own knowledge about its states of awareness, consciousness or erudition. On the other hand the mental states that have been referred to above are by themselves a product of the reasoning processes over incomplete or unknown information; an argument may not only be evaluated in terms of true or false, but it may be quantified over the interval [0, 1] (e.g. agent is able to deal product with agent using the set of conditions C1; however it is not known if it can do the same thing with a set C2 -leading to further confrontation) [15].

This work is supported by the developments in [19] where the representation of incomplete information and the reasoning based on partial assumptions is studied, using the representation of null values to characterize abnormal or exceptional situations. The identification of null values emerges as a strategy for the enumeration of cases, for which one intends to distinguish between situations where the answers are known (true or false) or unknown [18, 19]. The representation of null values will be scoped by the ELP. In this work, it will be considered two types of null values: the former will allow the representation of unknown values, not necessarily taken from a given set of values, and the later will represent unknown values, taken from a given set of possible values. Consider the following as a case study to show some examples of how null values can be used to represent unknown situations. In what follows it will be considered the extensions of the predicates that denote some of the properties inherited by an agent, aiming at a measure of its credibility:

```
truthful: Entities × Value
good: Entities × Value
honest: Entities × Value
intelligent: Entities × Value
competent: Entities × Value
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where the first argument denotes the agent and the second represents the value of the property (e.g. truthful(paul, 100) denotes that the truthfulness of the agent paul has the value 100).

```
truthful( paul,100 )
¬truthful( E,V ) ←
        not truthful( E,V )
```

Program 1: Extension of the predicate that describes the truthfulness of an agent.

In Program 1, the symbol ¬ denotes the strong negation, denoting what should be interpreted as false, and the term not designates negation-by-failure.
Following the example given by Program 1, one can admit that the truthfulness of the agent cesar has not been established. This situation will be represented by a null value, of the type unknown, that should allow one to get the conclusion that the truthfulness exists, but to which it is not possible to be affirmative with respect to its value (Program 2).

```
truthful( paul,100 )
truthful ( cesar, ⊥ )
¬ truthful ( E,V ) ←
      not truthful ( E,V ),
       not exception(truthful ( E,V ) )
exception(truthful ( E,V ) ) ←
      truthful ( E, ⊥ )
```

Program 2: Information about the truthfulness of the agent cesar, with an unknown value.

Symbol ⊥ represents a null value of an undefined type, in the sense that it is a representation that assumes that any value is a potential solution but without being given the clue to conclude about which value one is speaking about. Computationally, it is not possible to determine, from the positive information, the value of the truthfulness of the agent cesar; under the description of the exception situation (fourth clause from Program 2, the closure of predicate truthfulness), it is discarded the possibility to be assumed as false any question on the specific value of truthfulness of the agent cesar.

Consider now the example in which the value of the truthfulness of an agent josé is foreseen to 65, with a margin of some mistake (15). It is not possible to be affirmative regarding the truthfulness value. However, it is false that the agent has value of truthfulness of 85 or 100. This example suggests that the lack of knowledge may only be associated to an enumerated set of possible values. On the other hand, consider the truthfulness of the agent francisco that it is unknown, but we know that it is specifically 25 or 50.

```
truthful ( paul,100 )
truthful ( cesar, ⊥ )
¬ truthful ( E,V ) ←
      not truthful ( E,V ),
       not exception(truthful (E,V ))
exception(truthful ( E,V ) ) ←
      truthful ( E, ⊥ )
exception (truthful ( josé, V ) ) ←
      V ≥ 50 ∧ V ≤ 80
exception (truthful ( francisco, 25 ) )
exception (truthful ( francisco, 50 ) )
```

Program 3: Representation of the truthfulness of the agents josé and francisco

To reason about the body of knowledge presented in a particular knowledge, set on the base of the formalism referred to above, let us consider a procedure given in terms of the extension of a predicate called demo, using ELP as the logic programming language. Given a question it returns a solution based on a set of assumptions. This meta predicate will be defined as:

demo: Question × Answer

where Question denotes a theorem to be proved and Answer denotes a truth value: true (T), false (F) or unknown (U) (Program 3).

```
demo( Q, 𝒯 ) ← Q
demo( Q, ℱ ) ← ¬Q
demo( Q, 𝒰) ← not Q ∧ not ¬Q
```

Program 4: Extension of meta-predicate demo

The first clause of Program 4 sets that a question it is to be answered with appeal to the knowledge base positive information; the second clause denotes that the question is proved to be false with appeal to the negative information presented at the knowledge base level; the third clause stands for itself.

Indeed, in the search for an answer, we are looking into the Case Based Reasoning (CBR) methodology for problem solving [21], and postulate that each case is to be given in terms of a logic theory, built upon the extensions and the exceptions of the predicates that make their realm, i.e. for all cases in the case's memory and for each property inherited by an agent, that is selected, and their relevance to the answer evaluated, in terms of a measure of the quality of the information it carries. The CBR life cycle is therefore defined as follows, in terms of the algorithm:

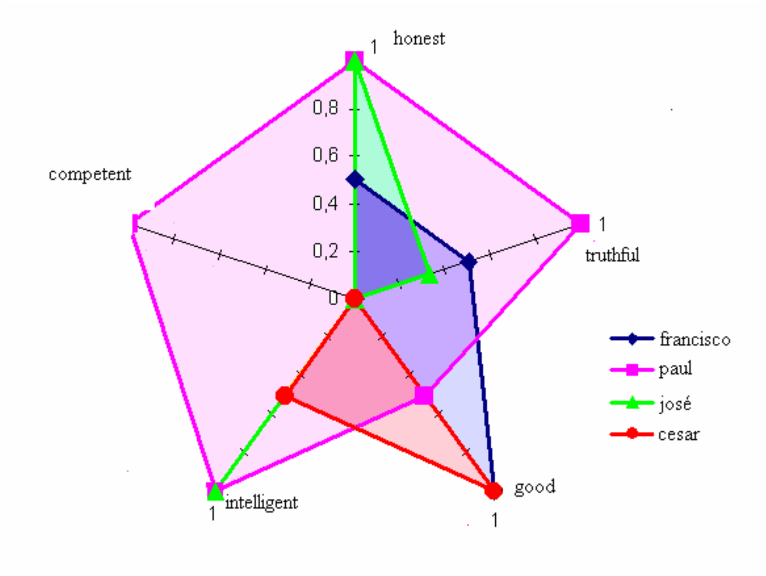

Figure 1 – A measure of the quality-of-information for the individual agents *francisco, paul, josé,* and *cesar (here presented in terms of different areas and colors)*

- A new case is set in terms of the agent's data, and given as the extension of a set of predicates and the exceptions to these extensions;
- The new case is re-defined in terms of the extension of an unary predicate $L_P/1$ that evaluates the agent`s quality of information with respect to a particular property (here given in terms of the subscript);
- Using L_P , a mapping into an hyperspace is built, where the axes stand for the agent`s state of knowledge, and the area delimited gives a measure of the quality of information carried out by each case under consideration (Figure 1).

i.e. using L_P and the extension of predicates *honest, competent, truthful, good* and *intelligent*, a mapping into an hyperspace is built, and the area delimited by the arcs gives a measure of the quality of information carried out by each case under consideration [20]. In the example of the Program 3, and to predicate *truthful,* this situation corresponds to a case where a measure of the quality of the information it carries is given by:

$L_{\texttt{truthful}}(\texttt{paul, V}) = 1$

$L_{\texttt{truthful}}(\texttt{cesar, V}) = \lim_{x\to\infty}\frac{1}{x} = 0$

$L_{\texttt{truthful}}(\texttt{jose, V}) = 1 - (75\text{-}55 + 1) / 100 = 0.29$

$L_{\texttt{truthful}}(\texttt{francisco,V}) = 1 / 2 = 0.5$

Similar calculi are to be made for the predicates *honest*, *competent*, *intelligent* and *good*.

5. IMPLEMENTATION

Using JADE a prototype has been developed in order to evaluate *credibility* and *trust* using the formalisms mentioned to above, in VE scenarios. Some print-screens are shown in Figure 2.

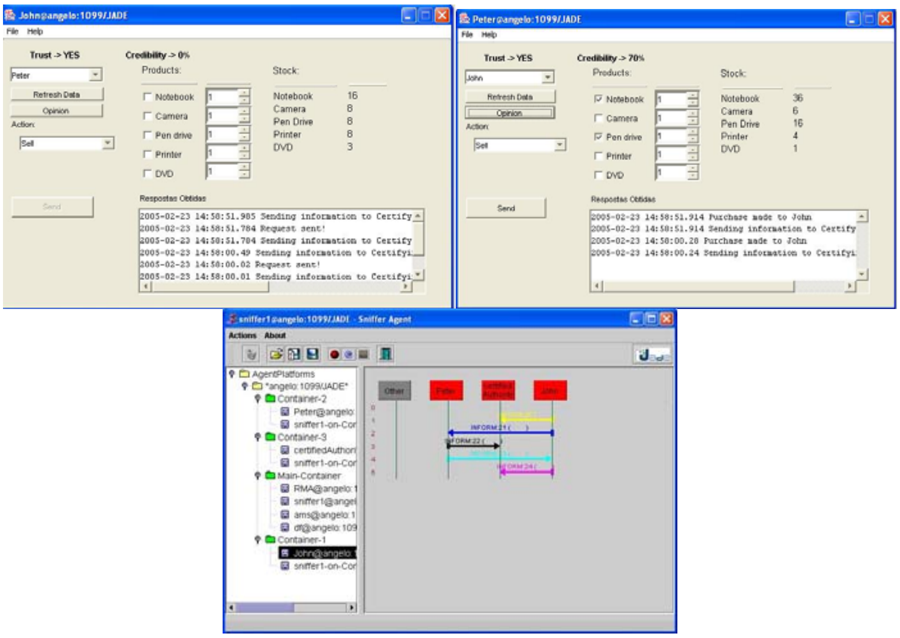

Figure 2 – Given a measure of the agent credibility and trust

6. CONCLUSIONS

This paper shows how to construct a dynamic virtual world of complex and interacting entities or agents, in which fitness is judged by one criterion alone: quality of information. The architecture underlying this system is versatile, creative and powerful enough to engender a practically infinite variety of data processing and analysis capabilities, adaptable to almost any conceivable intellectual tasks. This virtual world could witness the emergence of a learning, thinking machine, and foray into a vast, untapped technological market.

In order to obtain a solution to a particular problem, one looks at a repository, in order to evaluate cases, based on a measure that is given in terms of the information quality carried out by each case. Usually important is that the logical system have associated with it a meta-theory, which would address questions such as whether the system in question is sound, complete, decidable, and so on. Such meta-properties are determined by bringing mathematical tools to bear on the system in question. In this work such a meta-theory was defined in terms of the extension of an unary predicate L_P that evaluates the credibility of each agent, in terms of the quality of information it carries and its contribution to the problem's solution.

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